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TITLE
SYSTEM AND METHOD FOR REMOVAL OF MATERIALS FROM AN ARTICLE

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BACKGROUND OF THE INVENTION

Reference to Related Application

[0001] This present application claims benefit from U.S. Provisional Patent Application Serial Number 60/412604 filed September 20, 2002 in the names of Thomas Johnston, Tim Vaughn and Pete Atwell entitled "Method and System for Oxidizing an Article at Low Pressure."

Field

[0002] The system and method of the present invention pertains to the manufacture of articles; more particularly, the removal of organic and organometallic materials from an article.

Background

[0003] Ultraviolet systems for removing organic materials such as polymers and photoresist from articles have been used for many years. Historically, most of the UV systems for removing organic or organometallic materials from articles have involved the use of 254 nm and 184 nm mercury lamp systems. In recent years, the development of systems for removing organic materials from an article has focused more on the use of dielectric barrier discharge lamps such as shown in U.S. Patent No. 5,510,158. These dielectric barrier discharge lamps are xenon lamps that emit light at 172-nm wavelength. It has been shown that ozone and activated oxygen can be produced by combining an oxygen-containing gas at a pressure of one atmosphere in the presence of xenon 172-nm wavelength source. It has also been show that the production of ozone and activated oxygen for the use in the oxidation

process consumes a large portion of the energy produced by 172-nm xenon wavelength source.

[0004] When organic or organometallic materials are located on the sidewalls of an article, removal of these materials is typically accomplished in a wet chemistry environment. The removal of organic or organometallic materials from an article in a wet chemistry environment can produce surface damage to the article as well as create hazardous byproducts.

[0005] The need remains for a commercially effective dry environment system and method that effectively removes organic and organometallic materials from the surface and sidewalls of an article at a rapid rate.

SUMMARY

[0006] The system and method of the present invention facilitates the dry environment removal of organic and organometallic materials, such as a polymer created by the semiconductor etching process and photoresist materials, from the surface and sidewalls of an article without the use wet chemistry or standard atmospheric oxidative processes.

[0007] An article with organic or organometallic materials, such as a polymer or photoresist, located thereon is placed into a vacuum reaction chamber. The vacuum reaction chamber contains an oxygen-containing gas at a reduced pressure of between about 50 mtorr to about 1500 mtorr. Located within the vacuum reaction chamber is an irradiation source. Typically, the irradiation source is a xenon gas dielectric barrier discharge lamp, which emits vacuum ultraviolet rays having a wavelength of about 172 nm. It is essential that the

irradiation source have the ability to withstand the low-pressure conditions within the vacuum reaction chamber.

[0008] The 172 nm xenon wavelength induces an intermolecular molecule energy transfer, thereby destroying the molecular bonds of the organic or organometallic material. The 172 nm energy in the presence of oxygen-containing gases creates ozone and activated oxygen. The products resulting from the destruction of the molecular bonds are then oxidized by the ozone and activated oxygen. The volatile byproducts created from this reaction with ozone and activated oxygen are abated from the article surfaces via the vacuum system. In addition to the removal of the reaction byproducts, the vacuum increases the amount of 172 nm energy at the surface of the article resulting in an increase in the overall reaction rate.

[0009] One advantage of the present invention over the prior art is the elimination of the need for wet chemistry in the removal of organic and organometallic materials, thereby eliminating the need for expensive solvents and environmentally destructive and potentially hazardous byproducts. Another advantage is the elimination of the use of plasma-based photoresist removal processes, thereby eliminating the potential for damage from electrostatic charging commonly found in plasma-based ashers. Yet another advantage is the increase in the overall reaction rate which is highly beneficial in a commercially viable post-etch cleaning process for semiconductor and reticle manufacturing.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0010] A better understanding of the system and method of the present invention may be had by reference to the drawing figures, wherein:

Figure 1 is a schematic view of a vacuum reaction chamber containing a dielectric barrier discharge lamp;

Figure 2A is a "before" picture of a metallic article before application of the present invention; and

Figure 2B is an "after" picture of the metallic article shown in Figure 2A after application of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0011] A better understanding of the present invention may be had by understanding that the ultraviolet photodissociation process produces high molecular breakdown rates of both organic and organometallic materials from the surface of article. The use of a xenon 172 nm wavelength lamp fragments hydrocarbon bonds by the process of intermolecular molecule energy transfer. This method of fragmenting of hydrocarbon bonds, as opposed to an oxidation method, allows for smaller, more volatile species to form at the reaction surface, thereby improving upon the use of an oxidative process for the removal of unwanted organic materials from the surface of the article.

[0012] It has been found that the placement of xenon 172 nm dielectric barrier discharge lamp directly into a vacuum reaction chamber allows the surface of an article within the vacuum reaction chamber to receive higher levels of energy than at atmospheric pressure. The receipt of these higher levels of energy was unattainable in atmospheric conditions because of the majority of energy transferred by the xenon 172 nm dielectric barrier discharge lamp was to the gas phase molecules (N_2 and O_2). It has been discovered that the use of a xenon 172 nm dielectric barrier discharge lamp at very low pressures from

about 50 mtorr to about 1500 mtorr allows for an extended life of activated oxygen, which is produced by a xenon 172 nm dielectric barrier discharge lamp ($O_3 \rightarrow O_2 + O$) or ($2O_2 \rightarrow O_3 + O$). The production of activated atomic oxygen O, which is a strong oxidizing agent, accelerates the overall reaction rate and creates a volatile species, which is removed by the vacuum system. The ozone O_3 and activated atomic oxygen O react with the organic and organometallic materials that have broken bonds via the intermolecular molecule energy transfer from the xenon 172 nm dielectric barrier discharge lamp.

[0013] To implement the use of a xenon 172-nm dielectric barrier discharge lamp in a vacuum reaction chamber, the lamp must have the structural strength to be placed in a low-pressure environment and encapsulate the xenon gas in an excimer state. In the preferred embodiment, and as shown in Figure 1, a vacuum reaction chamber **20** is constructed with single or multiple lamp 172 nm lamp sources **22**, vacuum inlet ports **24**, particle gas inlet ports **26**, a single wafer or reticle stage **28**, and TC or thermogauge inlets **30**. The system for producing vacuum within the vacuum reaction chamber **20** includes a two-stage 300 L/min pump **30** or some variation thereof.

[0014] In the preferred embodiment of the system described, the photodissociation process caused by the UV light source performs the below resist etches.

[0015] According to the photos attached at Figures 2A and 2B, the system and method of the present invention removes polymers created by the metal etch process along with the complete removal of the photoresist material such as a SPR-700 Shipley photoresist material. The sample which appears in the photographs at Figures 2A and 2B is a Silicon wafer that contains a 1K of titanium, 3K of titanium tungsten, plus 6K of aluminum with

0.5% copper (1KTi/3K TiW w/ 6 K Al Cu 0.5%) that was etched with a Lam Researcher Corporation etcher with no pacification process.

[0016] The system and method of the present invention not only removes sidewall polymer and photoresist material from the surface of the article in a dry environment, but allow for such removal without damaging the article surfaces.

[0017] While the present system and method has been disclosed according to the preferred embodiment of the invention, those of ordinary skill in the art will understand that other embodiments have also been enabled. Such other embodiments shall fall within the scope and meaning of the appended claims.